THE AUK:

A QUARTERLY JOURNAL OF

ORNITHOLOGY.

VOL. XIV. APRIL, 1897. NO. 2.

THE SPRING PLUMAGE OF THE BOBOLINK, WITH REMARKS ON 'COLOR-CHANGE' AND 'MOULTING.'[1]

BY ARTHUR P. CHADBOURNE, M. D.

Plate I*a*.

In a recent note 'On the Spring Plumage of the Bobolink'[2] Dr. Allen has apparently overlooked a record (Skillen, Auk, XI, 1894, p. 180), which shows that the change to breeding dress is not always accompanied by an increased feather-loss, nor in this case at least was new feather-growth evident. In short there seems to have been not even a 'partial moult,'[3] and hence the individual feathers must have changed in color.

My own experience with captive Bobolinks confirms the above statement; but unfortunately of three Bobolinks kept during the winter of 1894–5, only one proved to be a male, while six males

[1] Read before the Nuttall Ornithological Club, May 17, 1896.

[2] Bull. American Museum Nat. Hist., VIII (March 18, 1896), pp. 43, 44.

[3] In the present paper the word 'moult' is to be understood as meaning that during or about the time of the renewal of the plumage, there is an *increased* shedding of the feathers, an evident growth of 'pin-feathers,' or both combined; but it *implies nothing as to feather-color and color-change.*

taken in June 1895, escaped by tearing a hole in the cloth top of the cage. However, through the kindness of Messrs. Allen, Batchelder, Brewster, Merriam, and others, I have been able to compare a series of more than 175 male Bobolinks, probably covering about the same localities and dates as the material used by Mr. Chapman in the preparation of his articles on this subject.[1] Among the skins loaned by the American Museum of Natural History was the specimen from Corumbá, Brazil, on which the hypothesis was originally based *that the black and white dress was entirely due to 'moulting' without any 'color-change' in the individual feathers.* The assumption being that 'moulting' is conclusive proof of the absence of any color-change,— a supposition which has been frequently used by writers on this subject, but one which is absolutely without proof of its correctness as yet, while it is shown to be untenable by examination of the Corumbá bird, as will appear later.

First as to my pet Bobolink, which was kept from January until the breeding plumage was complete : — The bird always seemed well and strong, and the *color-change was* NOT *accompanied by any increase in feather-loss, i. e.*, not greater than during the winter and often for several days in succession there were no cast-off feathers at all to be found. The total during the three weeks that the change was in progress was *thirteen*, — namely two broken rectrices and eleven contour feathers. It is hardly possible that any stray specimens were unnoticed, for even had they fallen outside of the cage they would have been found in the room, and a wire netting protected the window. 'Pin-feathers' could hardly have been overlooked, if present; for I often held the bird in my hand and carefully examined it, blowing back the plumage until the skin could be seen. It is also safe to say, doubtless, that the cast-off feathers were not eaten by the bird itself. Hence it follows that unless the previous plumage was made up of only two tail and eleven body feathers, both of the former on the same side, — which was certainly not the case, — *my Bobolink was unquestionably an instance of color-change in the plumage without 'moult.'*

---

[1] *Cf.* Auk, VII, 1890, pp. 120–124; also *ibid.*, X, 1893, pp. 339–341.

The possibility of a spring 'moult' being entirely overlooked is worth considering at this point. If we assume for the moment that none of the old feathers change to the color of the breeding dress, and that all which are unlike those of the preceding plumage, have replaced old feathers already 'moulted,' can we then form any idea of the loss during the development of the spring dress of the male Bobolink? In other words, how many feathers would a Bobolink lose during a *complete* 'moult'? I have tried to estimate this approximately in a male Bobolink, killed May 30, by carefully pulling out, one by one, all the contour feathers from the two ventral feather-tracts, including the 'inner lateral,' but neither the 'humeral' nor the 'gular tracts' of Nitzsch;[1] and then gluing each separately on sheets of paper. Both my patience and mucilage gave out by the time I had finished the sheets in question, — about one third of the under parts of the bird.[2] The contour feathers on the sheets amounted to 439 in all, none of which, judging from their color alone, could have formed a part of the winter dress. The feathers on the upper breast, neck, and throat are smaller, and must be relatively more numerous; and it is certainly safe to estimate the total loss from the abdomen, breast, and throat, at three times actually counted, making the total 1317. The back and upper parts must increase this number by at least one half; and *the hypothesis of a 'moult without color-change' would therefore imply a loss of 2634 feathers for the development of the full spring plumage of the male Bobolink.*

If the process lasted from three to six weeks — (it was three weeks from the time the first black spot appeared, until the full plumage of my Bobolink has been attained by color-change

[1] Pterylographia. (English translation by Sclater.) Publications of the Ray Society, London, 1867, p. 26, seq.

[2] It will be noticed that in this estimate the plumage of the head, wings, legs, and tail has not been included. The flight feathers, because they are often broken accidentally, and cast off by cage-birds when not 'moulting'; those of the head and legs, because they are so small as to be easily overlooked; while by omitting the remainder of the wings and tail, and counting the total loss from the upper parts as only one half that from the gastræum, my result must be an underestimate.

alone),— there would be *between 115 and 57 additional cast-off feathers in or near the cage each day.* It is hardly supposable that anyone at all interested in the question of a spring 'moult' could fail to detect its presence with such evidence daily before him during at least three weeks.

In the living bird, accurate data of the loss before and during the progress of a complete 'moult,' are, I believe, unpublished, for any of our native species certainly none are known to me for the Bobolink; and as my bird did not 'moult,' it is impossible to supply the deficiency. But the record of a pair of tame Screech Owls (*Megascops asio*), shows well how sudden may be the onset, and how great the loss during the period of a complete feather-change; and it will also be noticed, that in this,— the only species of which we have exact data,— the total number of loose feathers *found* while the change was most active, exceeds our *theoretical* estimate based on the skin of the Bobolink.

AVERAGE NUMBER OF FEATHERS FOUND PER OWL.[1]

From July 24 to July 31 — ave. daily ½ feather.
" August 1 to Aug. 7 — ave. daily 5 feathers.
" Aug. 8 to Aug. 31 — ave. daily 9¼ feathers.
" September 1 to Sept. 30 — ave. daily 9 feathers.
" October 1 to Oct. 28 — ave. daily 9½ feathers.
" " 29 to Nov. 2 — ave. daily *93 feathers.*
" November 3 to Nov. 30 — ave. daily 90¼ feathers, varying between 81 and 95.
From December 1 to Dec. 7 — ave. daily 17¼ feathers.
" " 8 to Jan. 11 — ave. daily 4 feathers.

During the time that 'moulting' was most active,— namely from Oct. 29 to Nov. 30,— a total of 2806 feathers were actually *found*[2] for each of the two Owls; yet their cage was much of the time out of doors and exposed to the wind, while being made of

[1] As there were two Owls, the numbers given are one half the feathers actually found in the cage.

[2] It may be well to state here that almost without exception the cast-off feathers were practically without any brown or tawny shades, though the bird was in well marked intermediate plumage; while the feathers in which there was considerable brownish, usually showed some mechanical injury, on careful examination.

half inch wire netting, some of the smaller specimens were doubtless blown away and lost, which could not have occurred in the case of the Bobolink. I was curious to know how closely the number of feathers of the 'Scops' agreed with that of the Bobolink, and therefore counted the corresponding pterylæ of the Owl in the way already described. The agreement was unexpected: — the Owl having 501 feathers on the sheets, and an estimated total of 3006 as needed for a complete 'moult'; contrasted with 439, and 2634 of the Bobolink.

Even Dr. Allen's note itself furnishes additional proof that a spring 'moult' would not escape detection. He says: "the molt was in all stages from birds showing only here and there the tip of a black feather on the breast to those that were in nearly full breeding plumage. A large number of these were in the highest stage of molt, pin feathers being distinctly visible . . . even when the birds were several feet distant."

Again in the Corumbá bird 'moulting' was so apparent that in the illustration for 'The Auk,' it was decided to assist Nature by having the 'moult' of the wings and tail completed by the artist. A convincing proof that a 'moult' could not have been overlooked, though hardly so of scientific accuracy; especially as it was also intended to change such of the under parts as were white to black or brown, had a slight mistake not prevented!!

All the evidence at hand is therefore against the possibility of error of observation in regard to the spring 'moult' of the Bobolink; and there seems to be no reasonable doubt that the apparently contradictory statements of Allen,[1] Chapman,[2] Ord,[3] Skillen,[4] and others are correct, though perhaps not yet satisfactorily explained. It follows *that Bobolinks differ as to 'moulting' in spring, — one bird attaining the full plumage by a 'true color-change,' another perhaps passes through a complete 'moult,' while in a third both processes are combined.*

It is however generally taken for granted, that because a certain bird has been found 'moulting' in spring, all individuals of the

[1] *L. c.*, p. 44.
[2] *L. c., antea.*
[3] Trans. Amer. Philos. Soc. III (1830), pp. 292–299.
[4] *L. c., antea.*

same species must 'moult' also; but have we any proof that this is the case? None whatever! The physical condition must vary in different individuals, be they men or birds; and hence the need of new feathers and the power of producing them, must vary also; and it is certainly more probable that Nature would be guided by the condition of the individual bird, than that the rulings of modern systematists would be followed. In short *some Bobolinks 'moult' in spring, others do not.*

To return to my Bobolink: — The first black spot appeared on March 28 and consisted of a single feather, which macroscopically and microscopically, was evidently not of recent growth, the edge being quite uneven and no remains of the enveloping sheath being present. (Plate I*a*, fig. 3.) Subsequent specimens were similar to it in all essential details. In some of the changing feathers the black first developed around several foci, scattered about the surface of the vane, from which the dark effect spread, until the isolated spots became confluent and the whole was the uniform black shade of the spring dress. In other examples the dark color gradually extended towards the periphery, starting from the proximal portion of true vane and medially from along the rhachis.[1]

In about three weeks from the time the first black feather was noticed the full black and white breeding dress of our familiar songster was complete. No chestnut was at any time seen on the breast or under parts, nor was there the white on the centre of the breast and abdomen, which is so prominent in the Corumbá bird.[2]

[1] As there was no feather-loss it seemed unnecessary to mark and follow up the intermediate steps through which any one feather passed; moreover, it is impossible to mark a feather without injuring it, and my previous attempts had not been encouraging. (*Cf.* Auk, XIII, Oct. 1894, p. 323.)

[2] The majority of the white feathers on the breast of the Corumbá bird showed no color except white in the vane proper — *i. e.*, exclusive of the downy parts of the feather, which were a pale slate color. Some of these white feathers were *not fully mature*, while others are more or less worn and of *old growth*. Even supposing that all the worn white feathers would have been 'moulted', those which were still immature would hardly be cast off before the time the Bobolink appears in the South when no such completely white feathers are normally found. My Bobolink showed none of this white marking on the breast or abdomen, nor did it have the chestnut shading, which is so prominent in

The buff edging of the breast feathers was never more than a narrow line, evidently owing to the absence of the long fugacious tips, which are so characteristic of the newly developed feathers, and it is therefore probable that spring males showing much buff suffusion beneath, have recently passed through a 'spring moult,' or at least through a partial 'feather-change.'

The dealer from whom I bought the bird told me, that "last fall he (the Bobolink) lost lots of feathers"; and added: "In spring Bobolinks don't often lose any feathers to speak of. Sometimes I don't believe they lose any feathers at all; and you can't see any pin-feathers either while they are getting black. But in autumn the pin-feathers stick out all over them. Once in a while though, I've seen one have a regular moult, just as they do in fall." The above was written verbatim at the time, and is further proof that *because one individual of a given species has 'moulted,' it does not necessarily follow that all individuals of that species 'moult' also.*

Turning next to the series of skins: — The only early spring material is from Corumbá, Brazil. The male already referred to (Coll. Amer. Mus. Nat. Hist., No. 32783,) taken March 1, shows new feather-growth in a marked degree; and as was pointed out by Mr. Chapman, 'moulting' was in full progress. It is however quite another matter to prove that no color-change was also going on simultaneously in any of the feathers; for *though without the loss of old feathers from the tracts concerned, — or in other words, in the absence of 'moulting,' — an alteration in color must be due to a color-change in the same feathers; yet it does* NOT *follow, on the other hand, that because a bird is 'moulting,' a color-change in the individual feathers — be they old or new — is thereby excluded.* In fact the Corumbá bird itself furnishes conclusive proof that just the reverse is the case; and on careful examination one finds here

---

the Corumbá specimen, and Dr. Allen says nothing of any similar coloring among the birds seen by him. When we call to mind the fact, — to be referred to later, — that the black of the Bobolink is really due to brown, instead of black coloring matter, — it is at once clear that the excess of chestnut and white show a lack of the normal quantity of pigmented matter; and it seems almost sure that in the Corumbá bird, we have not a normal example, but a partial albino!

and there old-growth feathers, which are black, like the breeding-dress (*cf.* fig. 1); and others of the new-growth, which are the color of the Reed-bird plumage (*cf.* fig. 2).

Male Bobolinks in autumn, after the cares of the breeding-season are over, would probably require a complete renewal of the plumage, and a color-change in the old-growth would hardly be expected to occur. Pin-feathers typical of the black summer dress can be occasionally found, however, if carefully looked for (*cf.* fig. 4), and apparently change to the color of the autumn plumage later (*cf.* fig. 5).

We have now seen that feather-change and color-change in some cases at least, do take place separately and entirely independent of each other, though the two are also often in progress at the same time. *Hence it necessarily follows that neither can be the direct cause of the other; but that color-change must be recognized as an independent process, entirely distinct from so-called 'moulting.'*

The color-changes in the feathers of the Bobolink, of which I have now I think given sufficient proof, are the less surprising, in view of the fact that the black feathers apparently contain *very little or no black coloring-matter.* Thin transverse sections through the exposed portion of the vane of black breast-feathers, when examined with a high magnifying power and a strong *white*[1] light, show that the seemingly deep black color is really due to a *brownish* pigmented material,[2] generally (always?) grouped superficially near the surface of the vane; to some extent also to the thickness of the part, and to the effect of the underlying structures. Thus in the black spring specimen the granules are peripheral and comparatively close together, though a smaller number are also found in the deeper parts; while in the autumn the granular

[1] The most satisfactory light I have tried for color work with the microscope is that from a clear sky, reflected from a mirror covered with a white, highly glazed paper, and hung at an angle outside of a north window.

[2] To show that there is a very large amount of brown coloring matter even in breast feathers of the deepest black, it is only necessary to place such a specimen between two pieces of clear glass, and hold it against a strong light. The greater part, — sometimes the whole, — of the contour portion will appear ochraceous, being brightest along the edges of the barbs and barbules, where the parts are thin. This last, however, cannot be seen without a good magnifying glass.

pigmented matter is more uniformly scattered throughout. (Compare figs. 6 and 7.)

No difference between the pigmented matter of the spring and fall feathers was detected by the usual chemical and microchemical tests, which will be described more fully in another connection.[1]

RESULTS: — Summing up the more important points brought out by our study of the spring plumage of the Bobolink, we have seen that: —

1. Color-change in the individual feather is *fact, not theory.*
2. 'Color-change of the plumage without moulting' is also *fact, not theory;* and the change to breeding dress in the male Bobolink sometimes takes place without a so-called 'moult.'
3. Different individuals of the same species vary as to 'moulting' when assuming the spring plumage; and the fact that one Bobolink 'moulted' is no proof that all Bobolinks do the same.
4. The contradictory statements of writers are accounted for by this individual variation; and such statements are not to be passed over as so-called 'errors of observation.'
5. Color-change and feather-change are two distinct processes, neither being the direct cause of the other; and each occurs separately, as well as both together.
6. So-called 'moulting' (whether based on pin-feathers or on feather-loss), does not prove the absence of color-change; but to be valid, the proof must be based on the loss of all the old feathers from the tracts concerned. No such evidence has as yet been recorded.
7. Microscopically, the black and the buff feathers of the Bobolink differ only in the massing of the brown pigmented matter nearer the surface of the former; while it is more uniformly distributed in the latter. The usual tests fail to distinguish the pigmented material of the breeding from that of the fall plumage.

[1] Since the above was written, I have obtained similar proof that the Indigo Bunting (*Passerina cyanea*) also shows a like "individual variation" in regard to its spring change of plumage, — a male having developed the full breeding dress without appreciable feather-loss; while another male, which I saw several times, had a considerable number of pin-feathers, and also many cast-off feathers in the cage.

In conclusion, I wish to add a few words on the subject of 'MOULTING' in its wider application: — First, it is most important to have an exact definition of the word '*moult*,' which has often been used with very different meaning; namely, for new feather-growth, of the whole, or of a part of the plumage, for feather-loss, for complete, or slight changes of color whether caused by feather-change, by true color-change, or simply from mechanical 'wear and tear,' and the shedding of the deciduous tips. The word 'moult' is too firmly established, and too convenient to be abandoned, but its use should be restricted to *the regular seasonal feather-change*, WITHOUT REGARD TO THE COLOR OR COLORATION OF THE PARTS CONCERNED; *and when not farther qualified, the shedding of all the feathers, including the large flight feathers, should be understood.* The expressions, '*feather-loss*,' '*new feather-growth*' and '*feather-change*,' are scientifically exact, they define themselves, and are the equivalents of German terms, already in use. Why should not these, or some similar words be adopted by us.

Second: — The meaning of 'COLOR-CHANGE' would seem to be sufficiently clear, yet it has been very differently interpreted by writers on the colors of feathers; and such sentences as, "color-change, aside from the effects of exposure and fading", are often used. Moreover, as a rule, those who are sceptical on the subject of 'color-change without moult,' refuse to admit that an alteration from a darker shade to a lighter tint is an instance of a change in color. Yet obviously, the development of a lighter color may be either a *true* color-change, in the most strict sense, or it may be purely mechanical with resulting loss of substance. As applied to feathers therefore, *any perceptible departure from the former shades and tints, or from their previous distribution, is a color-change.* When used in connection with the subject of 'color-change without moult,' however, it is clearly intended to exclude alterations due to causes, acting from outside the body, and mechanically; and thus limited, A TRUE COLOR-CHANGE *is wholly, or in part due to conditions within the organism, or within the feather itself; to alterations in the coloring-matter, or in its distribution in the feather.*

Third: — FADING, *as already stated, implies a gradually progressive change from a darker shade to a lighter tint, resulting from conditions external to the body.*

Without a definite understanding on these points, any rational discussion of the colors and color-changes in feathers, must of necessity be both unprofitable and misleading.

SUPPLEMENTARY NOTE. — It has been suggested that an outline of the results of a more detailed study of the alterations on which changes in color in the feather depend is needed to complete the present paper.

1. *The mature feather* (*i. e.*, one which has reached full functional development), is far from being "dead and dry," "a foreign body no longer connected with the vital processes in the rest of the organism," as has sometimes been asserted; for during *its* life it receives a constantly renewed supply of fluid from the parts around it. In strong contrast to this is the really dead feather, in which this fluid matter is deficient, as for example, the majority of uninjured cast-off feathers. Some of the evidence in support of these facts may be of interest: —(*a*) The fatty or oil-like droplets on the surface of the feather can be shown by microchemical tests (staining, etc.), to be, some of them identical with the oil from the so-called 'oil-gland'; while others are totally unlike that secretion, and these latter are alone found exuding from the pores on the surface of the rami, radii, and shaft. The pores, some with drops of varying size issuing from them, show best at the distal ends of the segments of the downy rays. (*b*) In the living bird the imported fluid can be colored, *its progress noted, and the feather stained intra vitam.* Soon after death this becomes no longer possible. To see the stain the microscope is usually necessary. Call this "osmosis," "capillarity," or what you please, it is none the less a *vital process*, in that it ceases soon after death, and must be studied in the fresh feather. (*c*) The broken tips of the rays forming the vane are, when fresh, capped by a mass of the fluid, which has escaped, leaving the part immediately below the stump pale from the loss of the fluid pigmented matter. (*d*) In museum skins this fluid matter gradually dries and by its consequent increase in density, and that of the feather tissues, the colors darken; while the freshness and gloss of life disappear. (*e*) The evanescent tints of some species, — notably the fading of the rosy 'blush' of some of the Terns, soon after life is extinct is due to the drying up or escape of this fluid, while the lost tint was

due to the physical effect of structure, the shrivelling and change of form would act on the light rays, and the former colors would be lost in consequence. Comparison of specimens of *Sterna paradisæa*, *S. dougalli* and other Terns in my collection, shows that examples having the 'blush' most marked are those in which the feathers are the least dry. Absolutely fresh specimens are hardly obtainable, owing to the destruction of these birds for the demands of fashion. It is probable that the same explanation will be found to be true in the fading of other species. (*f*) Other substances than red pepper (*cf.* Auk, XIV, 1896, p. 33) when given with the food, also produce changes in the color of the feather and in its composition, recognizable by proper tests. This applies to other species than the Canary.

2. *Change of color in the individual feather after maturity.*— How the colors of feathers can change; the *modus operandi* of the process, has long been an ornithological stumbling block, but the explanation is, I believe, neither incredible, nor complicated, and in fact most simple and easily accounted for by well known physiological laws. It may be briefly summarized as follows:—(*a*) As the result of retrograde or other activity within the cells, and with or without the action of the imported fluid, new pigmented products are formed, which may be solid matter or may be in solution, but are unlike those previously present. (*b*) Vital conditions within the organism determine the composition of the fluid supplied to the feather, as well as the amount of the supply; and hence indirectly regulate the character of the new compounds in the feather, into which the fluid enters or which depend upon its influence. Thus at the mating season there would be an alteration in the amount and character of the fluid received by the feather, and a freshening and often a color-change quite distinct from a more or less complete feather-change, and in some cases without any associated 'moulting,' which would be a separate process, even if present.

EXPLANATION OF PLATE Ia.

(NOTE:—Figs. 1, 2, 4, and 5 were first photographed, and the prints from the negatives then colored from the original specimens; thus insuring absolute accuracy in outlines. They are about twice the natural size. Fig. 3 was outlined with a camera lucida to secure exactness, and

then colored from nature. It is a little enlarged. Figs. 6 and 7 were drawn and tinted from specimens under the microscope.

It is a pleasure to acknowledge my indebtedness to Mr. Baldwin Coolidge for the care and skill with which he has reproduced the original colors. Fig. 3 is by the author.)

Figure 1. Spring color-change without 'moult' of the feather. An old feather of the color of the spring plumage. (March 1, Brazil, Corumbá. Coll. American Mus. Nat. Hist., No. 32783.)

Figure 2. Spring 'moult' without color-change in the feather. A new-growth feather the color of the winter dress. (March 1, Brazil, Corumbá. Same skin as preceding.)

Figure 3. Spring color-change without 'moult' of the feather. The first black feather seen on my Bobolink. (March 28, cage-bird.)

Figure 4. Fall 'moult' without color-change of the feather. A new feather, but the color of the preceding plumage. (August 29, Minnesota. Coll. Amer. Mus. Nat. Hist., No. 52326.)

Figure 5. Fall 'moult' with partial color-change of the feather. A new-growth feather, showing the 'foci' of darker shade, partly obscured by the yellow of the fall dress. (August 2, New York. Amer. Mus. Nat. Hist., No. 32785.)

Figure 6. Spring feather, transverse section. From a deep black feather of the breeding dress, in its terminal third. Granules of coloring matter, chiefly massed peripherally, producing the effect of black. (May 30, Mass. Coll. A. P. C., No. 2672.)

Figure 7. Fall feather, transverse section. Like Fig. 6, but of the Reed-bird type. Granules not massed peripherally, but scattered throughout. (September 17, Mass. Coll. A. P. C., No. 3522.)

(Figs. 6 and 7 with Zeiss 4 mm. apochromat. objective, and No. 6 comp. ocular.)

REMARKS ON THE SPRING MOULT OF THE BOBOLINK.

BY FRANK M. CHAPMAN.

IN his paper on "The Spring Plumage of the Bobolink, with Remarks on 'Color-Change' and 'Moulting,'" published in this number of 'The Auk,' Dr. Chadbourne has shown that captive